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ELECTROMERISM, A CASE OF CHEMICAL ISOMERISM RESULTING FROM A DIFFERENCE IN DISTRIBUTION OF VALENCE ELECTRONS[1]

RECENT advances in our knowledge of the structure of matter have made it possible for an organic chemist to address a group of non-organic chemists and of physicists upon this subject without apologizing. During a period which is not far behind us in the past, not only the validity, but, possibly, even the utility of employing structure conceptions requiring atoms and their arrangements was brought into question; so that the organic chemist, who has maintained an abiding faith in atoms and a confidence in his ability to decipher something of their arrangements in molecules, became aware of an indulgent smile whenever he broached this subject except in the company of his own confrères.

With this inheritance, it is natural to expect that the organic chemist would welcome any discoveries which make our conception of atoms and of the mechanism by which atoms combine to form molecules more concrete; and that he would be among the first to seek to apply these concepts to special problems in his own field.

With a feeling of keen satisfaction, therefore, we learn through the work of Bragg that, in a diamond crystal, each carbon atom is surrounded by four other carbon atoms placed equidistant from it. These atoms are grouped around the central carbon atom as the four corners of a

[1] An address prepared for the symposium on the "Structure of Matter," held at the meeting of the American Association for the Advancement of Science in New York City, December, 1916.

regular tetrahedron are arranged around its center. Thus, the tetravalent character of the carbon atom manifests itself clearly. Furthermore, when a model of a diamond crystal is examined, it is discovered that the atoms appear to arrange themselves in rings of six. These relationships suggest at once well known fundamental theories of the organic chemist.

Through the writings of J. J. Thomson,[2] Stark,[3] Abegg[4] and many others, the conviction has been reached, that the forces which hold the atoms together, commonly called chemical affinity, are chiefly, if not wholly, electrical in character. The impetus to this interpretation has come from the discovery that electricity itself possesses an atomic structure, and that our material atoms appear to be composed of units of positive and negative electrical atoms nicely balanced in the neutral atom. As Carl Barus says:[5]

> Not only has energy possessed herself of inertia, but with ever stronger insistence she is usurping the atomic structure once believed to be among the very insignia of matter. Contemporaneously matter, itself, the massive, the indestructible, endowed by Lavoisier with a sort of physical immortality, recedes ever more into the background among the shades of velocity and acceleration.

Electrochemical theories have not been lacking in the development of chemistry. For many years the electrochemical theory of Berzelius was a guide in the interpretation of chemical phenomena. There is, perhaps, no greater tragedy recorded in the annals of science during the past one hundred years than that which overtook Berzelius at the close of his active career as leader of chemical thought. We of to-day know best why this theory failed, and why we are now busily engaged in formulating a new electrochemical theory, as well as a new electrophysical theory. In fact, J. Stark in his recent work, "Die Elektrizität im chemischen Atom," gives a eulogy of Berzelius, and points out the many striking qualitative resemblances which the theory of Berzelius bears to his own.

The special purpose of my remarks today precludes any detailed discussion of the various theories concerning the structure of the atom. This phase of the subject has already been presented in the morning meeting of this symposium. It may be said that all theories agree upon a positive core or nucleus associated with negative electrons, the atoms of negative electricity. Thomson presents hypotheses concerning the possible arrangements within the atom, while Stark limits his treatment chiefly to the surface layer. The surface layer, he says, contains an excess of positive electricity. In the neutral atom one or more electrons, called valence electrons, are held close to the surface of the atom by this positive charge. Compounds are formed, when the lines of force from one or more of these valence electrons reach out and end on the positive areas of other atoms. In the case of strongly polar compounds, an electron is almost wholly drawn over to the atom which it then holds combined.

Lewis[6] classifies compounds into polar and non-polar, but in a footnote remarks:

> It must not be assumed that any one compound corresponds wholly, and at all times, to any one type.

He distinguishes between valence number and polar number. Valence number he defines as the number of positions, or regions, or points (bond termini) on the

[2] J. J. Thomson, *Phil. Mag.*, March, 1904, 27, 757 (1914), etc.

[3] J. Stark, "Die Elektrizitut im Chemischen Atom," Leipzig, 1915.

[4] Abegg, *Z. Anorg. Chem.*, 39, 330 (1904); 50, 309 (1906).

[5] Science, N. S., Vol. XL., 727, 1914.

[6] G. N. Lewis, *J. Am. Chem. Soc.*, 38, 762 (1916).

atom at which attachment to corresponding points on other atoms may occur. Polar number is the number of negative electrons which an atom has lost (in an algebraic sense).

The evidence of, perhaps, indeed, the cause of the mobility of polar compounds is the freedom of one especially important atom, the atom of electricity, or the electron, to move from one position to another.

From a study of the reactions of chemical compounds, and in particular of organic compounds, it seems doubtful whether the classification into polar and non-polar based upon physical values, such as the dielectric constants[7] of compounds in the gaseous state, is of any more significance than the terms electrolyte and nonelectrolyte were to the older supporters of the theory of Arrhenius. In time, it came to be known that it was no easy matter to draw the dividing line between these two classes, and that one class seemed to merge imperceptibly into the other. So, with polar and non-polar compounds, it seems theoretically probable that there is no perfectly non-polar compound, unless it be a molecule composed of two like univalent atoms, such as hydrogen;[8] and that other compounds are polar in varying degrees, depending upon the mutual attractions between valence electrons and the positive surfaces or cores of the atoms combined, and upon the distances to which these electrons, in forming such compounds, are deflected from their normal positions relative to the positive areas of the uncombined atoms themselves.

Even before the electron theory had been proposed, an application of the theory of ion formation and charges upon ions led to the recognition of polar characteristics in compounds not known to be ionogens.

In a study of chloroamines, RNHCl and R_2NCl, Seliwanow[9] observed that, during hydrolyses, the chlorine in these compounds was replaced by hydrogen; and that they interacted with hydrogen iodide with the liberation of two equivalents of iodine for each equivalent of combined chlorine,

$$R_2NCl + 2\ HI = R_2NH + HCl + I_2.$$

Usually, during hydrolysis, combined chlorine in organic compounds is exchanged for hydroxyl and has no tendency to liberate iodine from hydriodic acid. Seliwanow ascribed this peculiar behavior of the chlorine atom in chloroamines to the fact that, *even in combination*, it existed as *"hypochlorous chlorine."* He pointed out that the chlorine atoms in nitrogen trichloride, NCl_3, also showed the same peculiar behavior.

In 1901, Noyes and Lyon,[10] in performing Hofmann's well-known lecture experiment for demonstrating the composition of ammonia, observed that, under certain favorable conditions, the amount of nitrogen liberated as free nitrogen was about one sixth, instead of one third, the volume

[7] Stark ("Die Elektrizität im Chemischen Atom," p. 29) says: "Between the properties 'dielectric' and 'conducting' there is a connection. In a dielectric medium, since there are positive and negative 'Quanten' bound to one another, it follows that the medium may become conducting when, through proper application of energy from without, the 'Quanten' pairs become partially dissociated, or ionized; that is, into freely moving positive and negative 'Quanten.' Conversely, the ions of a conducting medium by mutual union to form 'Quanten' pairs may make the medium dielectric; and in general a material medium is at the same time dielectric and conducting, so that by assigning a dielectric constant and a specific conductivity, the medium is characterized for a finite electric field and a finite electrical current."

[8] Bohr concludes that the hydrogen molecule consists of two hydrogen nuclei (at a distance apart of 0.60×10^{-8} cm.), and two electrons which revolve in an orbit in a plane perpendicular to the line joining the nuclei.

[9] Seliwanow, *Ber.*, 25, 3612 (1892).

[10] W. A. Noyes, A. C. Lyon, *J. Am. Chem. Soc.*, 23, 460 (1901).

of the chlorine used. They explained this reaction by the following equation:

$$12\,NH_3 + 6\,Cl_2 = N_2 + NCl_3 + 9\,NH_4Cl.$$

This observation led them to study the chemical properties of nitrogen trichloride. They found that each chlorine atom present in nitrogen trichloride was equivalent to two atoms of "available chlorine," or, as Seliwanow had put it, the chlorine is hypochlorous in character. Noyes and Lyon represented nitrogen trichloride as follows:

$$\begin{array}{l} -+\mathrm{Cl} \\ \mathrm{N}-+\mathrm{Cl} \\ -+\mathrm{Cl} \end{array}$$

and, to account for the reaction between ammonia and chlorine, assumed that ammonia may *ionize* in two ways,

$$\begin{array}{l} + \\ \mathrm{N}+ + 3\mathrm{H}^- \rightleftarrows \mathrm{NH_3} \rightleftarrows \mathrm{N} \equiv + 3\mathrm{H}^+ \\ + \end{array}$$

and, furthermore, that the chlorine molecule may ionize to give both positive and negative chlorine ions.

In the same number of the *Journal of the American Chemical Society*, Stieglitz[11] commented upon the work of Noyes and Lyon, and put forth arguments to show that this reaction,

$$H_2O + Cl_2 \rightleftarrows HCl + HOCl,$$

a reversible reaction, was, at the same time, an *ionic reaction*. In other words, hypochlorous acid may ionize in two ways, amphoterically,

$$\begin{array}{l} \mathrm{HOCl} \rightleftarrows \mathrm{H}^+ + \mathrm{OCl}^- \\ \mathrm{HOCl} \rightleftarrows \mathrm{HO}^- + \mathrm{Cl}^+. \end{array}$$

The chlorine molecule, therefore, must yield negative chlorine ions, Cl^-, and, also, positive chlorine ions, Cl^+.

These deductions, expressed originally by Noyes and Lyon, as well as by Stieglitz, in terms of ion formation, have since been translated into the language of the electron theory of valence. Thus, the chlorine molecule may be represented electronically by the symbol, $\mathrm{Cl}-+\mathrm{Cl}$.

The striking difference in behavior of derivatives of positive chlorine and of negative chlorine may be illustrated by comparing the two compounds, nitrogen trichloride and phosphorus trichloride, which, by virtue of the family relationship of nitrogen and phosphorus in the periodic system, and the similarity in the formulas of the two chlorides, would be expected to resemble one another in chemical behavior about as closely as any two compounds could. At the same time, the illustration will serve to explain the significance of the statement made in an earlier part of this paper, viz., that the polar characteristics of compounds may be revealed by a study of their chemical interactions.

If the electronic formulas,

$$\begin{array}{l} -+\mathrm{Cl} \\ \mathrm{N}-+\mathrm{Cl} \\ -+\mathrm{Cl} \end{array} \qquad \begin{array}{l} +-\mathrm{Cl} \\ \mathrm{P}+-\mathrm{Cl} \\ +-\mathrm{Cl} \end{array}$$

are assigned to these two substances, we obtain formulas which, unlike those in general use, show why it is that the two compounds are most dissimilar in chemical deportment; why nitrogen trichloride, when hydrolyzed, gives ammonia and hypochlorous acid, while phosphorus trichloride yields phosphorus acid and hydrogen chloride; why the chlorine atom in nitrogen trichloride possesses oxidizing properties, while the chlorine in phosphorus trichloride does not. The oxidizing value of a positive chlorine atom corresponds to a gain of two negative electrons, if a negative chlorine ion is the final stage in the change.

$$\mathrm{Cl}^+ \rightarrow \mathrm{Cl} \rightarrow \mathrm{Cl}^-.$$

Certain other halogen compounds have been found to show similar polar differences. Thus, Nef[12] observed that chlorocyanogen, upon hydrolysis, gave hydrogen chloride and cyanic acid, while iodocyanogen gave hypoiodous acid and prussic acid,

[11] Stieglitz, *J. Am. Chem. Soc.*, 23, 797 (1901).

[12] Nef, *Ann.*, 308, 320 (1899); *ibid.*, 329 (1899).

$$\begin{matrix} Cl-+CN & + & H+-OH= \\ & & \quad H\ +-Cl & + & HO-+CN, \\ I+-CN & + & H+-OH= \\ & & \quad HO-+\ I & + & H\ +-CN. \end{matrix}$$

Tetrabromomethane and tetraiodomethane, when hydrolyzed, give bromoform and iodoform, respectively:

$$\begin{matrix} Br_3C-+Br & + & \overset{+}{H}O\overset{-}{H}= \\ & & \quad Br_3C-+H & + & HO-+Br, \\ I_3C-+\ I & + & \overset{+}{H}O\overset{-}{H}= \\ & & \quad I_3C-+H & + & HO-+I. \end{matrix}$$

Iodine monochloride reacts as follows:

$$I+-Cl+H^{+}-OH=HO-+I+H+-Cl.$$

In fact, there is no difficulty in finding among organic compounds countless cases in which the polarity manifests itself clearly during chemical changes. Thus, in the case of alkyl cyanides, RCN, it may be asked what indication there is in the formula itself to lead chemists to predict, unerringly, that the products of hydrolysis of such a compound are always ammonia and a carboxylic acid. Pure speculation would suggest that at least four different sets of products are possible:

(*a*) $RC(OH)_3$ and NH_3;
(*b*) $RCH(OH)_2$ and NH_2OH;
(*c*) RCH_2OH and $NH(OH)_2$;
(*d*) RCH_3 and $N(OH)_3$.

But the substances expressed under (*a*) are the only ones ever realized. That this decision is not inherent in the formula is emphasized all too forcibly by the fact that these four sets of products are the very ones which beginning students offer to explain the hydrolysis of an alkyl cyanide. In terms of the electron conception valence, the explanation lies in the fact that the nitriles are polar compounds of the formula:

$$RC\begin{matrix}+-\\+-\\+-\end{matrix}N$$

In this connection, some recent experiments on mercury dialkyls carried out with Mr. Werner in our laboratory have led to the observation that, upon complete hydrolysis in the presence of acetic acid, the products formed are *metallic mercury*, an *alcohol*, and a *hydrocarbon*. At about 200°, mercury diethyl decomposes to give mercury and butane. This dissociation implies that the mercury atom in these dialkyls either possesses, or readily assumes, the condition of reduction which it has in the metallic state, viz., with an equal number of positive and negative "charges." This suggests, also, that the two ethyl groups may be one negative and the other positive:

$$Hg\begin{matrix}-+C_2H_5\\+-C_2H_5\end{matrix}=Hg\ +\ C_2H_5+-C_2H_5.$$

When mercury diethyl is heated with acetic acid, further evidence in support of this inference is furnished; a quantitative yield of metallic mercury is found, and in addition, ethane and ethyl alcohol (or acetic ethyl ester). These changes may be expressed in terms of the electron conception of valence as follows:

$$Hg\begin{matrix}-+C_2H_5\\+-C_2H_5\end{matrix}+\begin{matrix}H+-OH\\H+-OH\end{matrix}=$$
$$Hg+\begin{matrix}HO-+C_2H_5\\H+-C_2H_5\end{matrix}+H_2O.$$

If these reactions of mercury diethyl are compared with those of zinc alkyls and of oxygen alkyls, the significance of the statement that the polar characteristic of compounds becomes manifest during chemical changes will be apparent. Thus, zinc alkyls are hydrolyzed to give exclusively *zinc hydroxide* and a *hydrocarbon;* oxygen alkyls give exclusively *alcohols.*

$$Zn\begin{matrix}+-C_2H_5\\+-C_2H_5\end{matrix}+\begin{matrix}H+-OH\\H+-OH\end{matrix}=$$
$$Zn\begin{matrix}+-OH\\+-OH\end{matrix}+\begin{matrix}H+-C_2H_5,\\H+-C_2H_5,\end{matrix}$$

$$O\begin{matrix}-+C_2H_5\\-+C_2H_5\end{matrix}+\begin{matrix}H+-OH\\H+-OH\end{matrix}=$$
$$O\begin{matrix}-+H\\-+H\end{matrix}+\begin{matrix}HO-+C_2H_5,\\HO-+C_2H_5.\end{matrix}$$

If, therefore, the atoms in compounds may function positively or negatively, in general a univalent atom, A, may be represented by two electronic symbols, $A+$ and

$A-$; and an atom whose valence is n may function in $(n+1)$ ways electronically. Thus:

$$O\overset{+}{+},\quad O\overset{-}{+},\quad O\overset{-}{-},$$

$$N\overset{+}{\underset{+}{+}},\quad N\overset{+}{\underset{-}{+}},\quad N\overset{+}{-},\quad N\overset{-}{-}.$$

A compound formed by the union of the univalent atoms, A and B, may be represented by two electronic formulas:

$$A+-B \text{ and } A-+B.$$

These two formulas represent isomers in a peculiar sense, quite unlike structural isomers. The difference lies solely in the distribution of valence electrons. Two or more compounds related in this manner have been called electronic isomers, or *electromers.*[13]

There is a certain resemblance between electromers and structure tautomers. While the transformation of one tautomer into another is accompanied by a wandering of an atom from one position in the molecule to a new position, the transformation of one electromer into another depends upon a more subtle change, viz., of electrons, or negative atoms of electricity, from one position to another within the molecule. Furthermore, it would be expected that, like tautomers, one electromer would be more stable than the other, and, in the majority of cases, that only one form might be capable of isolation, but that under certain favorable conditions, both electromers might be realized.

Moreover, between two electromers there might exist a condition of equilibrium similar to that which exists between tautomers and desmotrops, viz.,

$$A+-B \rightleftarrows A-+B.$$

Many cases requiring an assumption of such a relationship have been observed. One simple illustration will suffice. When benzene sulphonic acid is subjected to the action of superheated steam, it yields benzene, C_6H_6, and sulphuric acid. But if the same sample is heated with caustic alkalies, the products are phenol, C_6H_5OH, and sulphurous acid (or sulphites). Since benzene and phenole, as well as sulphurous acid and sulphuric acid, are related as oxidation-reduction products, the question arises what is the electronic formula of benzene sulphonic acid? To account for the substances formed in the two reactions, it must be assumed that two electronic formulas may be assigned to benzene sulphonic acid, and that the two substances represented by these formulas are in equilibrium as *tautomeric electromers*[14]

$$C_6H_5-+SO_3H \rightleftarrows C_6H_5+-SO_3H.$$

It is self-evident that the problem of preparing two or more electromers presents far greater experimental difficulties than the separation of structure tautomers has offered in the past. When, therefore, it is recalled that von Baeyer observed the first case of tautomerism while studying isatin, and that many years elapsed before two compounds related as tautomers were actually separated as distinct substances (desmotrops), it should not be a matter of surprise that the preparation of actual electromers has not been more successful so far.

The first set of experiments, and practically the only ones, carried out with the express purpose of preparing electromers, are those of W. A. Noyes.[15] Noyes tried to prepare a nitrogen trichloride in which the chlorine atoms, like those in phosphorus trichloride, are negative

$$N\begin{matrix}+-Cl\\+-Cl\\+-Cl.\end{matrix}$$

No conclusive evidence in support of the

[13] Fry, *Z. Physik Chem.*, 76, 387 (1911).

[14] L. W. Jones, *Am. Chem. J.*, 48, 26 (1912).

[15] W. A. Noyes, *J. Am. Chem. Soc.*, 35, 767 (1912).

existence of such an electromer could be found.

In an article[16] published in the *Journal of the American Chemical Society*, I presented evidence, which I believe to be conclusive, to show that the certain derivatives of hydroxylamine, prepared by Meisenheimer, represent the first known cases of electromers, viz., compounds identical in structural formulas, but dissimilar in chemical and physical properties by virtue of a different arrangement of valence electrons, and the concomitant differences in force fields within the molecules.

A consideration of the properties of hydroxylamine, and its various derivatives and, in particular, the peculiar behavior of the hydroxyl group in such compounds, led me to conclude that this hydroxyl group could not be regarded as identical with negative hydroxyl, —OH. This opinion was expressed by Stieglitz.[17]

> The similar behavior of hydroxlamine and halogen amines, of hydroxylamine and hydrogen peroxide, still more the fundamental similarity existing between hydroxylamine and ammonia, and between their salts, and above all, the fact that, as far as the writer is aware, no hydroxylamine derivative has been found to exchange hydroxyl for halogen by treatment with halogen acids, or phosphorus halides, are facts upon which the writer's views are based. (According to a later private communication from Dr. Jones, he has now reached the same conclusion in this question and has discovered further evidence supporting it.)

These facts all imply that the hydroxyl group in hydroxylamine may be positive, $+O-+H$,

$$\begin{matrix} & -+H \\ N & -+H \\ & -+OH. \end{matrix}$$

Compounds of the formula $R_3N(OH)X$[18] are found among the products which result when hydroxlamine is treated with halogen alkyls. Moist silver oxide converts these substances into hydrated amine oxides, $R_3N(OH)_2$, H_2O. The same hydrated amine oxides may be prepared by the action of hydrogen peroxide[19] upon tertiary amines, R_3N. In fact, Hantzsch and Hillard[20] suggested that hydrogen peroxide might react with tertiary amines by addition and that the reaction may be reversible.

$$(CH_3)_3N + HOOH \rightleftarrows (CH_3)_3N(OH)_2.$$

By careful dehydration of hydrated amine in vacuo, amine oxides, R_3NO, are formed.

These amine oxides and their hydrates are oxidizing agents, and in this property show a striking resemblance to hydrogen peroxide. In fact, Dunstan and Gaulding, in summing up their behavior, say:

> We conclude that the oxygen is in an "active" condition analogous to the oxygen atom in hydrogen peroxide.

Thus, trimethylamine oxide rapidly decomposes in two ways:

$$2(CH_3)_3NO = 2(CH_3)_3N + O_2,$$
$$(CH_3)_3NO = (CH_3)_2NH + CH_2O.$$

These changes, looked at from the point of view presented by the electron theory, would lead to the inference that the oxygen atom in amine oxides should be represented as follows: $R_3N \rightleftarrows O$; and that the hydrated amine oxides, or their salts, should receive the following formulas: $R_3N \begin{matrix} OH. \\ X \end{matrix}$

If the hydroxyl group in hydroxylamine be regarded as positive, and if this condition of the hydroxyl group be retained in the alkyl (aryl) derivatives, two inferences concerning the behavior of substituted hydroxylamines must follow logically.

In the first place, compounds containing in their formula the group N—OH, or the

[16] L. W. Jones, *J. Am. Chem. Soc.*, 36, 1268 (1914).

[17] *J. Am. Ch. Soc.*, 36, 288 (1914).

[18] Dunstan and Goulding, *J. Chem. Soc.*, 69, 839 (1896); 75, 1005 (1899).

[19] Merling, *Ber.*, 25, 123 (1892); Wernick Wolffenstein, *Ber.*, 31, 1553 (1898); Mainlock and Wolffenstein, *Ber.*, 33, 159 (1900).

[20] Hantzsch and Hillard, *Ber.*, 31, 2058 (1898).

group N — OR, should show different physical and chemical properties, depending upon the nature of the hydroxyl, or alkoxyl group; *i. e.*, whether it is negative (I.) or positive (II.).

$$\underset{\text{(I.)}}{N+-O-+R}, \qquad \underset{\text{(II.)}}{N-+O-+R}.$$

Then, again, provided one of the hydroxyl groups is positive and the other negative, compounds of the type, $(R)_3N(OH)_2$ should exist in two isomeric forms (electromers) when one of the hydrogen atoms is replaced by a single radical R; and, furthermore, there should be two distinct isomers (electromers) if two of the hydrogen atoms are replaced simultaneously by dissimilar radicals, R and R′.

$$(R^+)_3 \equiv N \begin{matrix} +-O-+H \\ -+O-+R \end{matrix}, \qquad (R^+)_3 \equiv N \begin{matrix} -+O-+H \\ +-O-+R \end{matrix},$$

$$(R^+)_3 \equiv N \begin{matrix} -+O-+R \\ +-O-+R' \end{matrix}, \qquad (R^+)_3 \equiv N \begin{matrix} -+O-+R' \\ +-O-+R \end{matrix}.$$

In the second place, compounds of the formula R, R′, R″, $N(OH)_2$, in which there are three different alkyl (or aryl) radicals linked to the nitrogen atom, should exist in *stereoisomeric modifications,* provided one hydroxyl group is *negative* and the other one is *positive.* By the action of an optically active acid, *e. g.,* d-bromocamphorsulfonic acid, or d-tartaric acid, a racemic compound obtained by synthesis should be resolved into a dextro- and a levo-modification. Optical activity might even persist in the corresponding amine oxides R, R′, R″, $N \rightleftarrows O$. Although the two hydroxyl groups are *structurally* alike, they are totally different *electronically.* Consequently, the nitrogen atom is linked to five different radicals, and, in this respect, compounds of these types may be compared to substituted ammonium derivations of the formula R, R′, R″, R‴, N — X, which have been resolved into optically active forms[21] repeatedly. Experimental evidence supporting both of these deductions has been presented quite recently.

1. *Electromers.*—In an article concerning the "Non-equivalence of the Five Valences of Nitrogen," Meisenheimer[22] describes the preparation of two isomeric compounds of the type

$$(R)_3N(OCH_3)(OH).$$

The *first* isomer was obtained by the action of methyl iodide upon trimethylamine oxide, and the subsequent replacement of iodine by hydroxyl. Thus:

1. $(CH_3)_3N=O + CH_3I = (CH_3)_3N=\overset{OCH_3}{\underset{I}{}}$,
2. $(CH_3)_3N\overset{OCH_3}{\underset{I}{}} + NaOH =$
$$(CH_3)_3N\overset{OCH_3}{\underset{OH}{}} + NaI.$$
$$(A)$$

The *second* isomer was secured by the action of sodium methylate upon the salt obtained by treating trimethylamine oxide with hydrogen chloride.

1. $(CH_3)_3N=O + HCl = (CH_3)_3N\overset{OH}{\underset{Cl}{}}$,
2. $(CH_3)_3N\overset{OH}{\underset{Cl}{}} + NaOCH_3 =$
$$(CH_3)_3N\overset{OH}{\underset{OCH_3}{}} + NaCl.$$
$$(B)$$

The two forms, (*A*) and (*B*), are identical *except for the order in which the hydroxyl groups and the methoxyl groups were introduced.* In (*B*), as Meisenheimer said, the methoxyl group is linked to the "*fifth* valence," or the one which usually engages the *acid radical;* while it is linked to the "*fourth* valence" in formula (*A*). But

[21] Le Bel, *Compt. rend.,* 112, 724 (1891); 129, 548 (1899); *Ber.,* 33, 1003 (1900); Wedekind, *Ber.,* 32, 517, 3561 (1899); 35, 766 (1902); 36, 3791 (1903); 38, 1838 (1905); Wedekind and Oberheide, *ibid.,* 37, 2712, 3894 (1904); Wedekind and Froelich, *ibid.,* 38, 3438 (1905); Pope and Peachey, *J. Chem. Soc.,* 75, 1127 (1899); Pope and Harvey, *ibid.,* 79, 828 (1901).

[22] *Ann.,* 397, 273 (1912).

these two substances are fundamentally different. This is easily demonstrated by a study of their solutions. When a water solution of trimethylmethoxyammonium hydroxide (*A*) was heated, it decomposed quantitatively in accordance with the following equation:

$$(A)\quad (CH_3)_3N\begin{matrix}-OH\ (5)\\-OCH_3(4)\end{matrix} = (CH_3)_3N + CH_2O + H_2O.$$

While trimethylhydroxyammonium methylate (*B*) showed a totally different behavior

$$(B)\quad (CH_3)_3N\begin{matrix}-OH\ (4)\\-OCH_3(5)\end{matrix} = (CH_3)_3N{=}O + CH_3OH.$$

In addition to these compounds, Meisenheimer prepared a number of isomeric mixed dialkyl compounds, with methyl, ethyl and propyl radicals, *e. g.*,

$$(CH_3)_3N\begin{matrix}-OCH_3\\-OC_2H_5\end{matrix} \text{ and } (CH_3)_3N\begin{matrix}-OC_2H_5\\-OCH_3\end{matrix}.$$

In every case, water decomposed compounds of this type to give a tertiary amine, an alcohol and an aldehyde; but, invariably, the radical which was eliminated as aldehyde was the radical which occupied "position four (4)" and the group eliminated as alcohol always occupied "position five (5)." Meisenheimer stated that he never obtained even recognizable traces of the aldehyde which should have resulted if the group attached in position five had separated in that form. His conclusions may be stated in his own words:

> Durch diese Reaktion ist bewiesen dass die beiden Alkoxygruppen nicht in gleicher Weise an das Stickstoffatom gebunden sind.

The key to these disputed relations is easily furnished in terms of the electronic conception, by assuming that the one hydroxyl (or alkoxyl group) is positive and the other negative; thus:

$$(A)\quad (CH_3{}^+)_3\equiv N\begin{matrix}-+O-+CH_3(4)\\+-O-+H\ (5)\end{matrix} = (CH_3{}^+)_3\equiv N\begin{matrix}-+H\\+-O-+H\end{matrix} + H_2C{=}O,$$

$$(B)\quad (CH_3{}^+)_3\equiv N\begin{matrix}-+O-+H\ (4)\\+-O-+CH_3(5)\end{matrix} = (CH_3{}^+)_3\equiv N{\rightarrow}O + CH_3+-O-+H.$$

It will be observed that the two groups, or, in the final analyses, the two oxygen atoms, upon which the electromerism depends, are not linked directly, but through a third atom, nitrogen.

$$RO+-\overset{\cdot\cdot}{N}+-OH \quad \text{and} \quad HO+-\overset{\cdot\cdot}{N}+-OR.$$

This is undoubtedly responsible for the relative stability of these electromers as compared with others in which the atoms of different polarity are directly connected; *e. g.*,

$$A+-B \quad \text{and} \quad A-+B.$$

Here, again, the analogy to structure tautomers appears. Chemists have failed to prepare desmotrops of prussic acid, and of many other compounds in which the wandering atom passes from one atom in the molecule to another directly linked to it.

$$HCN \rightleftarrows CNH.$$

The majority of successful separations of desmotrops lie among compounds in which, similar to the electromers described above, tautomeric changes involve two atoms not directly linked, but connected by a third atom. Thus, in the keto-enol and in the nitro-nitronic acid desmotrops,

$$O{=}C-CH_2 \rightleftarrows HO-C{=}CH$$
$$O{=}N-CH \rightleftarrows HON{=}C-$$
$$\quad\ \|\quad\ \|\qquad\quad\ \|\quad\ |$$
$$\quad\ O\qquad\quad\ O$$

the wandering hydrogen atom passes from carbon to oxygen not directly linked.

2. *Stereomers.*—Meisenheimer[23] was the first to observe that amine oxides with three different radicals R R′ R″N = O, could be resolved into enantiomorphous modifications. Amine oxides of this kind were prepared by oxidizing tertiary amines with hydrogen peroxide, or Caro's acid. Meis-

[23] Meisenheimer, *Ber.*, 41, 3973 (1908); *Ann.*, 385, 117 (1911); 399, 371 (1913).

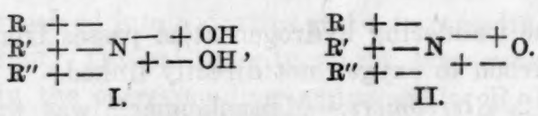
enheimer and his coworkers prepared methylethylaniline oxide, methylethyl-β-naphthylamine oxide and other similar compounds,

$$(CH_3)(C_2H_5)(C_6H_5)N=O$$
$$(CH_3)(C_2H_5)(C_{10}H_7)N=O.$$

The racemates were resolved by means of d-bromocamphorsulfonic acid or d-tartaric acid. After fractional crystallization and separation, each salt was converted into the active picrate, which was changed to the corresponding active chloride and finally into the active amine oxide itself.

Previous attempts to resolve compounds with two like radicals, Na_2bcd, have been fruitless. Even compounds more closely allied to these amine oxides in form, such as N-methylpicolinium salts, N-methylquinolinium salts, could not be resolved by H. O. Jones.[24] Meisenheimer takes it for granted that an explanation of the stereoisomerism is provided when he has called attention to the fact that, in the amine oxides, the doubly bound oxygen engages the valence which usually holds the acid radical, while in the case of the compounds studied by H. O. Jones, only non-ionizable valences have been satisfied by doubly bound carbon.

It seems that a more consistent explanation may be offered in terms of the electronic viewpoint, if the amine oxides and their hydrates are assigned the following formulas:



I. II.

It must be assumed that the linking in formula II. is similar to the grouping in formula I., in so far as its effect upon the asymmetry of the molecule is concerned, since amine oxides dissolved in benzene often show large rotations. The nitrogen atom, in either even, *does not hold two like groups*, since the properties of positive and negative hydroxyl are as divergent as those of positive and negative chlorine. In this respect, the conditions are not the same as those in ammonium compounds of the form, Na_2bcd, but are comparable to the condition existing in ammonium compounds of the general type, *Nabcde*.

In conclusion, permit me to express the belief that chemists will soon come to realize more fully that the recent investigations into the structure of the atom have a practical bearing upon their particular problems. The study of electromers, and the investigations of the conditions under which they may be prepared, certainly furnishes an inviting field of research, which, in my opinion, is worth tilling, and can not fail to be productive of results of far-reaching importance to chemists. Furthermore, with our present limited knowledge of the subject, no one can predict in what manner the discoveries, sure to be made, may react to modify and clarify our theories concerning the structure of matter, and, in particular, our vague notions of "chemical affinity."

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[24] H. O. Jones, *J. Chem. Soc.*, 83, 1400 (1903).

RECENT PHYSIOLOGY AND THE WAR[1]

This theme, kindly suggested by Professor Sir James Dewar, is sufficiently large to preclude more than a succinct treatment of some outstanding points in the time permissible in a single lecture. But these points are of considerable interest and have a more than fleeting importance.

The first is that of fatigue, its measurement and incidence in factory employees. The indices taken have been speed of output and quantity of output by groups of workpeople working under the conditions of a munitions factory. An inference of

[1] Address before the Royal Institution of Great Britain, February 2, 1917.

practical value drawn from the observations is that when the number of working hours per week was reduced from sixty-two to fifty-six the output actually increased. The reduction of the length of the working day by one hour per diem gave a rise of the total output of the week from an amount stated numerically as 6,150 to an amount expressed as 6,759. The output per hour increased 22 per cent. The kind of work in this case was "heavy," namely, deep screw-cutting by hand.

In another case, that of 200 women turning aluminium fuse-bodies, the reduction of the working hours per week from 68.2 to 60 notably increased the total output, and of course still more the rate of output. From these and other examples the lesson seems to be that there is for manual labor a certain length of working week, or working month, best suited for satisfactory production in permanence. The length varies with the class of the manual work. If a good efficiency is to be maintained in the factory this "most favorable" length of working month has to be followed. Before that it has to be found out and measured.

The next point raised was the influence of alcohol on the workers' output. The question has at present been attacked only in the laboratory so far as physiology is concerned. Physiological experiment shows that even a large single dose of alcohol—*e. g.*, 40 c.c.—has little or no effect upon the muscles *per se*, but that it does impair the working of the nervous system which actuates the muscles.

A suitable test in respect of the simplicity of the nervous centers involved in it is the knee-jerk. This is a familiar reaction to every physician; it is a reflex act, the spinal center for which has been thoroughly investigated. The effect of a single dose of alcohol of 30 c.c. quantity diluted with 120 c.c. of water is to diminish and render sluggish the knee-jerk; the speed of the response is sometimes decreased by 9.6 per cent., the amplitude of the response lessened by 48.9 per cent. The greatest impairment of the reaction was noted about one hour after the dose.

Another test of the effect of alcohol on the musculo-nervous actions was furnished by a very simple voluntary act. The person subjected to the experiment was required to move one finger to and fro, that is, to bend and straighten the finger alternately, as rapidly as possible. The rate of movement was examined before and after taking a dose of 30 c.c. alcohol diluted as above. This dose impaired the rate at which the oscillatory movement of the finger could be performed. The rate was diminished an hour after the dose by 8.9 per cent.

Such a movement is not well calculated to test that form of skill which consists in precision. Reasons were adduced for thinking that a precision of movement is that aspect of a muscular act which will be most detrimentally interfered with by alcohol. The testing of alcohol effect by the ergograph seems to show that a moderate dose, say 30 c.c. of alcohol, in a person accustomed to moderate use of alcohol, does not appreciably impair the power of the movement nor its resistance to fatigue. But the movements chosen as suitable for ergographic record are such as give little opportunity for the exhibition of precision or of skill of any kind.

The next point dealt with was the attempt to devise some fluid which can be injected to counteract the effect of severe loss of blood in the wounded. The properties desirable for the required fluid were shown to be: harmlessness in respect of avoidance of causing clotting in the circulation; restoration of the volume of the fluid in the circulation; maintenance of the due degree of viscosity of the circulating fluid, since on that factor depends the arterial and

capillary pressure; and, finally, preservation of the balance between the osmotic pressure of the fluid inside the blood-vessels and outside in the tissues. It was shown that considerable success had been reached in this problem by the experiments of Professor Bayliss and others.

A final point dealt with was the treatment of tetanus by administration of "anti-tetanus serum." This serum is obtained from the blood of horses which have been subjected to gradually-increasing doses of tetanus-toxin, the poison produced by the tetanus-bacillus. The high efficiency of this anti-toxic serum when used as a prophylactic was first demonstrated on man on a large scale by its employment in the first autumn of this war. Curves illustrating the statistics were shown. The severe outbreak of tetanus which ensued in the troops at the outset of the campaign was checked and practically stopped almost instantaneously by the orders that every wounded man, as soon as possible after being wounded, that is to say, at the first field casualty-station, should receive a small injection of anti-tetanus serum from the immunized horse. But the efficacy of the serum when once signs of tetanus have appeared in the patient is far less satisfactory. The remainder of the lecture was devoted to discussion of why this should be, and in what ways the difficulty may be, at least in part, overcome.

Charles S. Sherrington

PRE-MEDICAL TRAINING IN CHEMISTRY[1]

As a country we are rubbing the sleep out of our eyes and wishing we had split the kindling and brought up the coal the night before. The alarm clock has been ringing for some time, but we have preferred our dreams of ease to the realities of necessities.

The medical profession is awake and trying to start the water boiling, but finds it can not lay the fire. The wood and coal are at hand, but the knowledge of their proper use is lacking. Now, more than ever, do progressive physicians realize the dependency of successful practise on a well-founded knowledge of the chemistry of the human body, and more than ever do they irritably contemplate their lack of preparation.

This lack of preparation in a science so obviously fundamental to rational understanding of the human mechanism as to require no elaboration, at present exists; that a continuation of this condition should be allowed is a parody upon our intelligence.

The futility of expecting the physician to utilize all possible sources of relief to suffering without a knowledge of the application of basic chemical principles to the body reactions is apparent.

It is equally as absurd to expect the medical student to appreciate or assimilate the possibility of chemistry being a practical science for his uses, if he does not have sufficient foundation in this subject before he enters the medical school. The medical school is fundamentally a school of applied science. It is where the individual is taught science as applied to the human body. Any attempt to teach a student biological chemistry without his having received an adequate foundation in the fundamental principles of chemistry in general, and to expect him to know much of anything when we are through with him, is as idiotic as to try to teach calculus to men who have yet to know algebra. The foundation must be laid in the pre-medical work.

It is only in recent years that the teaching of elementary chemistry has been dropped from the medical curriculum. Unfortunately however even to-day it is only the few schools interested in turning out doctors instead of groups of men competent to pass State-board examinations, that have adapted themselves to the logical demand of the times as justified by the ever-increasing applicability of chemical

[1] Read before the Division of Biological Chemistry, American Chemical Society, Boston, September, 1917.

science to medical practise, and brought about this necessary change.

It is admitted that plausible excuse for this disorderliness exists. The appearance of chemistry as a real aid to diagnosis and treatment from the Stygian darkness has been not only remarkable for the rapidity of its development, but amazing in its stability. A new phase in medical knowledge has been produced through the pressure of the discoveries of countless investigators. And it is not surprising that the now should-be obsolete system clings tenaciously to the older but invalid conceptions.

It is well recognized that the efficient practise of medicine entails a scientific knowledge of ever-widening scope. It is therefore of the greatest importance that a proper selection of scientific information be presented to the prospective medical student for his assimilation. Purposeless instruction, from the point of view of the pre-medical student, is haphazard and yields results that are worse than nothing.

Conscientious objectors will mentally raise the objection that the pre-medical requirements are already well set down in the regulations of the various medical schools and by the American Medical Association. From the quantitative standpoint this is largely true, but from the point of quality the field is barren. And whereas these dicta were sufficient for the time and admirable in that an appreciation of the increasing importance of chemistry to the practise of medicine was shown, yet such advantages are now possible to be derived from a more exact definition of requirements that a change is imperative, else stagnation will set in. For mark you, while directions are given that so much inorganic, and so much organic, and so much advanced chemistry should be given, nothing is said about what of inorganic, and what of organic or what of advanced should be taught. To chemists it is a matter of individual experience that any of the various branches of the science can well occupy the studies of a lifetime.

So why try to make the pre-medical student a chemist. He wants to be a doctor, and he wants to learn what of chemistry there is that can help him to be a better doctor. But instead of getting what he wants he is put through the mill with the students who wish to enter upon chemistry as a life work, gets so far and no farther, wonders what it is all about, takes a good dose of physic in the form of an examination and gets rid of all he had taken in. If the college instructors of pre-medical students should look upon them as a problem in research, the results would never see the light.

Now this pre-medical training in chemistry is essentially a question of *what* instead of *how much*, and the decision as to the subject-matter to be offered for utilization is not especially difficult if one cares to look into a biological chemistry for a few hours. What the pre-medical student needs is to learn the fundamental principles common to all chemical reaction. He does not need encyclopedic details. Principles are to details as granite is to points in the work, they should not be obscured by a fog of wearying and relatively unimportant details. Let me illustrate: the understanding of the nature of oxides is a principle, the number and formulæ of the oxides of iron is an unessential detail, and again, the phenomena of isomerism is a principle, the ability to enumerate all possible isomerides of a given compound is detail.

Principle must not be subordinated to detail.

Human health and happiness rests to a great degree in the physician's hands. The true physician must be a true diagnostician. He can not be a diagnostician if he lacks power of observation and ability to carry on deductive reasoning. Where better can he gain this fundamental training than in chemistry? And can he get this point of view in a mind befuddled with inconsequential detail? Another essential attribute of the efficient doctor is technique. The ability to rapidly, smoothly and accurately carry on delicate manipulations is a prime requisite for adequate medical service. What teaches this better than intensive training in quantitative analysis? Can we conclude from the results handed over to us that these things have been done? We can not.

Any teacher of biological chemistry in a medical school knows how flimsy a chemical structure has been erected in the minds of the students coming to him, and that the information acquired is about as useful as is a cobweb for catching fish.

The causes of this are self-evident. Probably the most satisfying reason lies in the newness of the possibilities of the application of the science of chemistry to diagnosis and treatment. The collegiate instructor has failed to appreciate the progressive utilization of chemistry by the biological sciences. There is a chasm between what the instructor knows and attempts to teach to the pre-medical student and what the pre-medical student needs. And as a result the student falls into the chasm, and is lost. It is the job of the collegiate instructor to bridge the gap through constructive cooperation. The medical-school instructor has not been sufficiently insistent on preliminary requirements from a qualitative standpoint, nor has he shown any special inclination to relate the needs of the situation. These facts when coupled with the disinclination of the college teacher of chemistry to break away from the classical and now obsolete methods of teaching and inaugurate a system adapted to the demands of the times give some explanation of what at present confronts us. There is at hand a supply of potential useful information that lacks efficient assimilation because of the lack of understanding of fundamental principles.

The remedies are obvious—an attempt by the collegiate instructor in chemistry to learn something of what chemistry is doing in biology, a measure of cooperation between teachers of biological chemistry and the pre-medical instructors, a willingness on the part of the latter to recognize the validity of the wishes of the former, an outline of preparedness from the qualitative point of view, and a realization that true preparedness rests on understanding, while understanding can only come when detail is subordinated to principle.

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SCIENTIFIC EVENTS

BRITISH EXPERIMENTAL STATION FOR FUEL RESEARCH

The Fuel Research Board of the Department of Scientific and Industrial Research has issued a report, signed by Sir George Beilby, the director of fuel research, describing the scheme of research they have adopted and their plan for the establishment of a fuel research station on an industrial scale.

It is stated in the London *Times* that in a previous report, which has not been published, they stated that they had in view two main lines of research: (1) A survey and classification of the coal seams in the various mining districts by means of chemical and physical tests in the laboratory, and (2) an investigation of the practical problems which must be solved if any large proportion of the raw coal at present burned in its natural state is to be replaced by the various forms of fuel obtainable from coal by processes of carbonization and gasification.

At one time it was thought that the former line of inquiry could be proceeded with in advance of the second, but further consideration has shown them to be so interdependent that they can be most satisfactorily dealt with side by side. However, in preparation for the organization of the first line of inquiry, an experimental study of standard methods for the examination of coal in the laboratory has been made, and as the result of work carried out for the board in the Fuel Laboratory of the Imperial College of Science a test has been elaborated which, by direct weighing and measurement, gives the yields of gas, oil, water and carbonaceous residue that result from carbonization at any definite temperature.

Among the problems to be investigated are:

1. Can the 35 to 40 million tons of raw coal used every year for domestic heating be replaced wholly or partially by smokeless fuel, solid or gaseous, prepared by the carbonization of this coal?

2. Can adequate supplies of fuel for the Navy be obtained by carbonizing the coal at present used in its raw form for industrial and domestic purposes?

3. Can supplies of town gas be obtained more economically and conveniently by methods of car-

bonization and gasification other than those now used in gas works?

4. Can electric power be obtained more cheaply if the coal used for steam raising is first subjected to processes of carbonization and gasification?

5. Will the more scientific development of the preparation and use of fuel, which would be implied in the successful working out of the foregoing questions, enable the peat deposits of the United Kingdom to take a serious place as economic sources of fuel for industrial purposes?

6. Can the use of gaseous fuel in industrial operations be forwarded by the development of more scientific methods of combustion in the furnaces, muffles and ovens used in metallurgical, ceramic and chemical operations?

Answers to these questions, the report points out, will be obtained only by coordinated research carried on the lines of a broad and well-considered scheme, but at the same time the Fuel Research Board think it is to be expected that solutions of some of the problems will be supplied by workers in the industries, and they would regard it as a great misfortune were the establishment of a government organization for fuel research to result in discouraging or in any way limiting the activities of outside workers or organizations.

It was realized that the conditions required for the research station could be fulfilled only by a site in the neighborhood of a large gas works. Some months ago the director of Fuel Research approached Dr. Charles Carpenter, the chairman of the South Metropolitan Gas Company, and subsequently Dr. Carpenter on behalf of the directors of his company, made the following very generous offer:

1. To lease the government at a peppercorn rent sufficient land at the East Greenwich gasworks for the erection of the research station.

2. To prepare drawings and specifications for the station on lines laid down by the board and to make contracts for its erection; and

3. To give every facility for the transport of coal and other supplies to the station and to take over at market prices the surplus products, gas, tar, liquor and coke, resulting from the operations of the station.

The site consists of a strip of level ground, about 250 feet wide by 700 feet to 800 feet long, situated on the main siding which connects the gas works with the South-Eastern Railways and possessing access to an existing road. The station, as planned, will be capable of any extensions required for future researches. Of the four acres to be leased, only one acre will be occupied by buildings under the present scheme. Further, a large part of the equipment of the buildings will be of a permanent character and will serve all the general purposes of a research station. Future extensions, therefore, will not repeat this permanent equipment, but will be based upon it.

THE COLUMBIAN INSTITUTE

THE great scientific bureaus of the government at Washington with their thousands of employees dealing with the country's problems in every branch of science, and the important learned societies and scientific establishments of the national capital, were influenced in their early growth and development in a greater or less degree by a scientific society which flourished in Washington during the early years of the last century. The Columbian Institute for the Promotion of Arts and Sciences, now all but forgotten, was the first learned society established in Washington, its organization dating from June, 1816, sixteen years after the occupation of the city as the federal capital, and less than two years after the invasion by the British troops. The population of Washington was at that time little more than 10,000, and the repair and reconstruction of the public buildings was still in the initial stage. The history, organization and achievements of this society are fully described in an interesting Bulletin of the United States National Museum by Mr. Richard Rathbun, assistant secretary of the Smithsonian Institution, in charge of the National Museum.

The objects of the Columbian Institute, which was chartered by Congress in 1818 for a term of twenty years, were as a whole very diversified, those specifically named in the beginning having been almost wholly of a utilitarian nature, such as the government has from time to time assumed and made the basis of the work of several scientific bureaus.

Four years later, however, an organization was adopted which gave to the Institute the latitude of a comprehensive learned society. Among all the activities planned only a few were in any way conspicuously carried out, in default of the necessary support, the most important and material of these being the establishment of a botanic garden and a museum. The former occupied the extreme eastern end of the Mall which then approached much nearer the capitol than at present, and included the site of the present United States Botanic Garden.

Starting with a cabinet of minerals which remained predominant in this connection, this feature soon developed into a general though small museum, containing specimens of zoology, botany, ethnology, archeology, fossils, etc. Transferred to the National Institution in 1841, some of the objects are now readily distinguishable in the United States National Museum, forming, it may be claimed, the nucleus of its collections.

The institute obtained its meeting places and accommodations for its museum mainly through the favor successively of the executive departments, the municipal government, and Congress. It was first located in Blodget's Hotel, containing the general post office and the patent office, followed by the treasury department and city hall, being finally assigned a permanent home, in 1824, in the western addition to the capitol building, which had just been completed. The use of the site for its botanic garden was also a grant from Congress.

However unfortunate in the realization of its ambitions, the Columbian Institute nevertheless occupied an enviable position among the earlier associations of this country for the breadth and importance of its object, even if they be regarded only in the nature of suggestions, which have since been so fully recognized in the organization of the government and elsewhere, and for its hearty and unselfish efforts to carry them out. The Columbian Institute owed its establishment and early successes to a masterful mind, that of Dr. Edward Cutbush, then a surgeon in the Navy, and the first president of the society, though acknowledgments are also due to Thomas Law for the suggestion of such a society at the seat of government.

The membership of this institute included a great many of the prominent men of every walk of life in Washington, among them John Quincy Adams, Andrew Jackson, John C. Calhoun, Henry Clay, and well-known representatives of the Army, the government service, the medical and other professions.

AWARD OF THE JOHN SCOTT LEGACY MEDALS AND PREMIUMS AND OF THE EDWARD LONGSTRETH MEDAL OF MERIT

The city of Philadelphia, acting on the recommendation of The Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Alfred Rishworth Tattersall, of London, England, for the "Midget" Marvel Flour Mill.

This device is a small and simple form of flour mill, designed to enable local millers to make a good grade of flour at a comparatively low cost. It is of especial value in farming communities in which the flour mills run by water power have been abandoned.

And has also awarded the John Scott Legacy Medal and Premium to Max Ulrich Schoop, of Zurich, Switzerland, for the Schoop Metal Spraying Process.

In this process, wire of some easily fusible metal, like zinc, is fed into a device called a spraying pistol. The wire passes through a tube and at its end comes into contact with burning gas, by which it is melted, and the molten metal is sprayed by an air blast upon the surface to be covered. The use of this process has been found to greatly increase the life of patterns for castings.

The John Scott Legacy Medal and Premium has also been awarded to Thomas A. McCall, of South Akron, Ohio, for his inventions embodied in the early development of the Hooven Automatic Typewriter, and to John H. Pillings, of Hamilton, Ohio, for his inventions and improvements embodied in its later development.

The Franklin Institute has awarded its Edward Longstreth Medal of Merit to The

Hooven, Owens, Rentschler Company, of Hamilton, Ohio, for the development of ingenious methods used in the manufacture of this typewriter.

This machine is capable of producing typewritten form letters much faster than they can be written in the ordinary way.

SCIENTIFIC NOTES AND NEWS

A SPECIAL board of chemists to investigate explosives, the uses of gases in warfare and to act as advisers to the Bureau of Mines, has been appointed. The board will study the problem of increasing the production of materials used in explosives manufacture and will advise the bureau in the operation of the recently enacted law regulating the sale of explosives. The members are: Dr. William H. Nichols, of the General Chemical Company, New York, chairman; Professor H. P. Talbot, head of the chemical department of the Massachusetts Institute of Technology; William Hoskins, of Chicago, a consulting chemist; Professor H. P. Venable, of the University of North Carolina; Professor E. C. Franklin, of Stanford University, and Dr. Charles L. Parsons, of the Bureau of Mines.

PRESIDENT J. G. SCHURMAN, of Cornell University, has announced that the State Food Commission, of which he is a member, had completed its organization. Its work is now in three divisions—production, under Commissioner Wieting; distribution, under Commissioner Mitchell, and conservation, under Commissioner Schurman. For each of these divisions a bureau has been established with a director at its head. Calvin Huson, a former commissioner of agriculture, heads the bureau of production, and Cyrus Miller, a lawyer of New York City, the bureau of distribution. Professor Howard E. Babcock, of the State College of Agriculture at Cornell, now director of Farm Bureaus, has been appointed director of the bureau of conservation. Professor Babcock will receive a leave of absence from the university for the period of his service with the Food Commission.

THE mission sent to France by the Rockefeller Foundation to assist in combating the threatened increase of tuberculosis has decided to work in three sections under the general direction of Dr. Livingston Farrand. The first section will establish in one of the arrondissements of Paris and in certain large provincial towns a complete antituberculosis organization consisting of dispensaries, clinics and laboratories, with provision for domiciliary attendance. This section will be directed by Dr. Miller. A second section, under Dr. Charles White, will undertake the distribution of assistance. A third section, under Professor Gunn, will be concerned with the education of the public; it has already commenced to organize traveling exhibitions, meetings and kinematograph displays.

THE British Industrial Research Committee of the Board of Education have made a grant to Professor G. H. Bryan, F.R.S., of the University College of North Wales, which will enable him to devote the whole of next session to the carrying on of some special research work in aeroplane construction of national importance. In the first instance Professor Bryan proposes to work at the University of Bristol.

THE following-named officers, Engineer Officers' Reserve Corps, are relieved from duty at the Engineer training camp, and will report by letter to the director, United States Geological Survey, for assignment to duty connected with military mapping: From Fort Leavenworth, Kans., Second Lieutenants Elmer LeC. Goldsmith, John W. Lewis, Edward J. Francis, Elmo N. Murphy, Carl R. French, William D. Lewis, and Charles B. Moore. From American University, District of Columbia, Second Lieutenants Charles M. Madden, Edward H. Stelle, Frederic E. Smith, Edward P. Asbury, George B. Davidson, Frederick W. Look, Gordon D. Cooke, Joseph W. Geary, Jr., and Walter K. Wood, and also Second Lieutenant Herman J. Switzer, Engineer Officers' Reserve Corps.

MR. A. H. GILBERT has accepted a position as a pathological inspector with the Federal Horticultural Board with headquarters at Washington, D. C. Mr. Gilbert was formerly

associate professor of botany at the University of Kentucky.

Under a grant from the American Association for the Advancement of Science, Dr. C. H. Kauffman spent the month of August, 1917, in the state of Colorado studying the genus *Cortinarius* for his proposed monograph. In September, Dr. Kauffman began his work as a pathological inspector with the Federal Horticultural Board with headquarters at Washington, D. C.

The Herbert Spencer Lecture for 1917 was delivered by Professor Emile Boutroux, member of the "Institut" and the French Acadamy, and Doctor of Letters of the University of Oxford, on October 20, in the Oxford University Museum. The subject of the lecture was "The relation between thought and action from the German and from the classical point of view." The lecture was delivered in English.

The Bradshaw Lecture on "The causes of disease" was given before the Royal College of Physicians on November 8 by Professor Ernest S. Reynolds, physician to the Manchester Royal Infirmary. The FitzPatrick lectures were delivered on November 13, 14 and 15, by Dr. Arnold Chaplin, known for his studies of the Napoleonic period, on "Medicine in England during the reign of George III."

Dr. J. S. Flett gives this year the course of twelve Swiney lectures on geology at the Royal Society of Arts on Tuesdays, Thursdays and Fridays, beginning on Tuesday, November 13. The subject is "The Mineral Resources of the British Empire."

Memorial services were held at Cornell University Medical College for the late Dr. Lewis A. Stimson, professor of surgery at the college from the time of its foundation in 1898 to his death on September 17, this year. Among the speakers were Mr. Elihu Root, President Jacob Gould Schurman, of Cornell; Dr. Gilman Thompson, professor of medicine, emeritus; Howard Townsend, president of the board of governors of New York Hospital, and Dr. Edward L. Keys.

Professor Edward Hull, LL.D., F.R.S., late director of the Geological Survey of Ireland, died on October 18, in his eighty-ninth year.

A bronze tablet commemorating Dr. Simon Baruch's connection with the campaign for public baths in New York City was unveiled at the Simon Baruch Public Baths, formerly the Rivington Street baths on October 29. The tablet was donated by Mrs. Belle Baruch through the Association for the Promotion of Hygiene and Public Baths. Borough President Marcus M. Marks made the address of acceptance in behalf of the city.

Nature states that the late Mr. Cawthron left £250,000 to the city of Nelson, New Zealand, for scientific research. The trustees are the bishop of the diocese, the member for the district, the mayor of Nelson, two chairmen of local bodies and a personal friend of the deceased. The site of the proposed institute has been purchased, and the appointment of a director and staff is under consideration. The object of the institute is, primarily, scientific research work for the benefit of the province of Nelson and the Dominion of New Zealand. The province of Nelson is mostly concerned with fruit, agriculture and minerals.

UNIVERSITY AND EDUCATIONAL NEWS

By recent decision of the court Wilberforce University has come into possession of $30,000 of the Charles Avery estate in Pittsburgh. The fund is to be used for endowment purposes.

Committees representing Leander Clark College, of Toledo, and Coe College, of Cedar Rapids, recently voted to merge these two institutions. Coe College will absorb Leander Clark with its endowment of about $250,000.

Sir William Tatem has given £25,000 for a laboratory at the University College of South Wales, Cardiff.

As has been already announced Dr. Ralph H. McKee has been appointed to take charge of the graduate work in industrial organic chemistry (department of chemical engineer-

ing) at Columbia University, New York City. Dr. McKee was at the head of the department of chemistry of the University of Maine from 1909 to 1916, leaving this position a year ago to enter commercial chemical work in New York City as head of the research department of the Tennessee Copper Company. While at Maine he initiated and developed the department for the making of pulp and paper, the first of its kind to be established in any college in this country.

THE personnel of the department of geology and mining engineering at Iowa State College, Ames, Ia., is now as follows: Head of department, Dr. S. W. Beyer, who is also dean of the division of engineering, vice A. Marston, now major of the Battalion of Engineers, Iowa National Guard; L. C. Hodson and Dr. S. L. Galpin, associate professors of mining engineering; H. F. Staley, professor of ceramic engineering; Dr. Chas. A. Mann, associate professor of chemical engineering; John E. Smith, assistant professor of geology.

DR. J. E. MARR, University lecturer in geology in Cambridge University, has been elected to the Woodwardian professorship of geology in succession to the late Professor McKenny Hughes.

F. DE QUERVAIN, professor of surgery at the University of Basle, has accepted a call to the medical faculty of Berne as successor to Professor Kocher.

J. JADASSOHN, professor of dermatology at the University of Berne, has been appointed professor in Breslau in succession to Professor Neisser, who died some months ago.

DISCUSSION AND CORRESPONDENCE

AN EXTRAORDINARY RAINFALL RECORD

DURING a recent visit to the Hawaiian Islands, I had occasion to do some collecting on Kauai, the northern island of the group. While there I made a trip to a region of such extraordinary precipitation that it seemed worthy of record.

The island is almost circular in outline, rather less than thirty miles in its greatest diameter. It consists for the most part of a plateau averaging about 3,500–4,000 feet in elevation, but rising to a little over 5,000 feet at Mt. Waialeale, almost in the center of the island.

As in all the Hawaian Islands the windward (NE.) side has a very heavy precipitation, while on the leeward side the rainfall is very light.

The central part of Kauai, culminating in Mt. Waialeale, has the heaviest precipitation of any station in the Hawaiian group, and can be equalled by very few regions anywhere, where rainfall data have been kept. In one year over 600 inches fell, and for the five years—1912–1916—the average was slightly more than 500 inches.

Waialeale is seldom free from rain clouds, and the precipitation is almost incessant. In consequence the whole region near it is a bog, partly covered with a forest of low trees, thickly draped with dripping masses of mosses and liverworts, but a good deal of the region, including the summit of Waialeale, is an open bog, covered with coarse grasses and sedges, with a few stunted shrubs and various characteristic bog plants.

TABLE I

Precipitation at Waialeale, Island of Kauai, Territory of Hawaii

Elevation above sea level 5,075 feet

Year	Rainfall in Inches
1912	399.35
1913	453.00
1914	610.00
1915	590.00
1916	539.70

Precipitation at Waimea Village, Island of Kauai, Territory of Hawaii

Elevation above sea level 10 feet

Year	Rainfall in Inches
1912	20.50
1913	23.58
1914	24.50
1915	13.40
1916	22.05

Distance Waimea to Waialeale (air line) 13.5 miles.

My guide on this expedition was Mr. W. V. Hardy, hydrographer of the United States Geological Survey, who has been keeping records

on Mt. Waialeale for the past six years. I am under great obligation to Mr. Hardy for many kindnesses, and I am indebted to him for the accompanying tables. The second table shows the rainfall data for Waimea, a village on the leeward coast of Kauai.

Douglas H. Campbell
Stanford University,
California

QUOTATIONS

THE ROCKEFELLER HEALTH RESEARCHES[1]

The third annual report of the Rockefeller Foundation, the International Health Board (known previously as the International Health Commission), deals with the year 1916. The general summary, which precedes the details of different states and countries, shows that in addition to ankylostomiasis, malaria and yellow fever have been dealt with, and this would seem to indicate that the Board is prepared to tackle all tropical disease where the necessity arises. As regards the first of these scourges, ankylostomiasis, it is stated that active measures to control and prevent the disease are now in operation in Kentucky, Louisiana, Mississippi, North and South Carolina, Tennessee, Texas, and Virginia in the United States; in certain West Indian islands —Antigua, Grenada, St. Lucia, St. Vincent, and Trinidad; in British and Dutch Guiana, Costa Rica, Guatemala, Nicaragua, Panama, Salvador, in South America; and in Ceylon and Siam in the East. Such widespread work, properly controlled as this is, and with no lack of funds to support it, is bound to do good, and, though remarkable results can not be looked for in a few years, nevertheless results will come, all in due time. To ensure this, permanency of the work is essential, as otherwise matters would quickly drift back. The sanitation of many of the small tropical towns and villages at the present day is very similar to that which existed in England a hundred years ago, and only time and much labor will bring them into line with modern sanitary ideas. As many tropical maladies are insect-borne, study of the habits of the insects concerned is essential, and engineering works, large and small, may be required to abolish their different breeding grounds. The importance of collective investigation and organized campaigns in such a task is manifest, and it is here that the great value of the efforts of the International Health Board lies. The report describes fully the means adopted in the fight against ankylostomiasis. Of great interest also is the work of the commission appointed by the board to inquire into the problem of yellow fever centers in South America. The report states that the only endemic center of the disease in South America at present is Guayaquil, Ecuador, though certain sections of Colombia, Venezuela, and the adjacent West Indian Islands are also under suspicion and require close observation. The eradication of the disease, with this knowledge as a guide, is feasible. The report suggests that Mexico and West Africa should similarly be examined. Experiments upon the control of malaria have also been commenced, and these will be extended in due course. Further, a new school of hygiene and public health has been established in Baltimore by the Rockefeller Foundation in connection with the Johns Hopkins University, and is to be opened this month with Dr. William H. Welch as director. Three main purposes will be served by the new school: first, to furnish trained men on whom the board may draw; secondly, to serve as a training center to which students from other countries may be sent for instruction; and, thirdly, to provide a laboratory for solving scientific problems which arise. This Rockefeller Foundation is a splendid conception. Untrammelled by questions of expense, its activities are unlimited, and the benefits it can and will bestow upon mankind in the tropics are inestimable. It is a dream the original workers in tropical medicine often dreamed, and it has come true. Finally, a word of congratulation is due to Dr. Wickliffe Rose, its able director-general, for the work he has already accomplished. Long may he continue to direct its energies.—*British Medical Journal.*

[1] N. Goormaghtigh, *Arch. méd. Belges*, Paris, 1917. Tome LXX., p. 697.

SCIENTIFIC BOOKS

On Growth and Form. By D'ARCY WENTWORTH THOMPSON. Cambridge University Press. 1917. 8vo. 779 pages with 408 text-figures.

In the author's own words the purpose of his book is to show "that throughout the whole range of organic morphology there are innumerable phenomena of form which are not peculiar to living things, but which are more or less simple manifestations of ordinary physical laws." This thesis Professor Thompson elaborates in a most interesting manner, developing with the aid of our fuller knowledge of physical forces and of the conditions under which they act, the mode of study initiated by Borelli many years ago, and applied, more recently, with striking and suggestive results, to several forms of organic activity by Rhumbler, Leduc, Przibram, Macallum and others. These results and many others less familiar receive clear exposition, but the book is far from being a mere compilation, a refreshing originality, being characteristic both in subject matter and in the manner of its presentation.

The contest between the vitalistic and mechanistic views of the phenomena of life has been carried on by generation after generation of men and always with the strategic results of the struggle in favor of the mechanists, as one vitalistic stronghold after another has fallen. The attack is drawing ever nearer to the central citadel and Professor Thompson's book is a massing of the attacking forces before this citadel. But the author with all his enthusiasm, recognizes limitations in his resources. "Nor do I ask of physics," he says," how goodness shines in one man's face and evil betrays itself in another. But of the construction and growth and working of the body, as of all that is of the earth earthly, physical science is, in my humble opinion, our only teacher and guide." Psychic phenomena are outside the limits of his attack. Even with this limitation, however, the book is one of the strongest documents in support of the mechanistic view of life that has yet been put forth.

It would be difficult to give an adequate résumé of the contents of a book, so crowded with facts and ideas of the greatest interest to morphologists; it must suffice merely to mention some of the problems treated. One finds an interesting discussion of the physical factors determining the size of organisms, especially interesting being the consideration of the conditions which may determine the minimum size of a living organism. This is followed by a chapter on the factors determining growth and then follow chapters on the structure and form of the cell, in which the phenomena of karyokinesis are regarded as "analogous to, if not identical with those of a bipolar electric field," and the forms assumed by organisms as expressions of the law that a liquid film in equilibrium assumes a form which gives it a minimal area under the given conditions. In this connection Professor Thompson expresses the opinion that in the simpler organism, whose form is due to the direct action of a particular physical force, similarity of form is not necessarily an indication of phylogenetic relationship.

The form of the cell in cell-aggregates is then taken up, the arrangement of the division planes being considered as illustrations of the principle of minimal areas, and the author then passes on to the consideration of concretions and spicules. This involves as an essential problem the question of crystallization in the presence of colloids, a question concerning which there is much yet to be learned. The further discussion of the forms assumed by spicules leads to their division into two groups, those of intracellular origin and those that are intercellular, linear growth of the former under restraint leading to forms which have for their mathematical basis geodetic curves, while in the case of the latter the phenomena of adsorption and the deposit of the crystalline material on interfaces are held to be sufficient for the explanation of even the marvellously complicated radiolarian skeletons.

The mathematical properties of the logarithmic spiral as applied to the forms shown

by molluscan and foraminiferal shells are then discussed and from this to a consideration of the form of horns and tusks the passage is easy. A brief discussion of phyllotaxis follows and is succeeded by a chapter on the shapes of eggs and other hollow structures, after which one finds an interesting description of the mechanical principles illustrated by the structure of individual bones and by the skeleton as a whole. The concluding chapter is an exposition of Professor Thompson's method of comparing the form of different organisms, or of their parts, by inscribing, for example, the outline of the skull of *Hyracotherium* in a system of Cartesian coordinates and then determining the deformation of the system necessary for a similar inscription of the outline of the skull of a horse. A graphic representation is thus obtained of the manner of growth characteristic of this particular line of evolution, and the method may thus serve in certain cases as a test of phylogenetic affinity.

This brief outline may give some idea of the scope of the book, but it altogether fails to indicate the interesting and suggestive manner in which the various topics are treated. Professor Thompson's style is marked by a clearness of expression which makes every page of interest and his book is one that may well be recommended as revealing food for thought and fields for investigation which have been too much neglected by students of morphology. J. P. McM.

Tsimshian Mythology. By Franz Boas. Based on Texts recorded by Henry W. Tate. Paper accompanying the Thirty-first Annual Report of the Bureau of American Ethnology, 1909–1910. Washington, Government Printing Office, 1916. Pp. 1037; 3 plates; 24 text figures.

The core of this paper consists of English versions of sixty-four Tsimshian myths and three war tales, written down for the author by Mr. Henry W. Tate, a Tsimshian Indian of Port Simpson, B. C., in his own language, between 1902 and the year of his death, 1914. The translations were made by Professor Boas on the basis of "a free interlinear rendering by Mr. Tate."

However, unlike most ethnologists who have published Indian stories, Professor Boas has not rested satisfied with the mere printing of "material," important as such publication undoubtedly is, nor even with the addition of comparative footnotes. He has made this work the occasion and the basis for studies of several different aspects of Tsimshian ethnology, and for what is by all odds the best investigation of the distribution of American myths and mythic elements which has so far appeared, one which goes a long way toward satisfying the often-voiced demand for a concordance of American myths. Besides the usual tables of contents, bibliography and alphabet explanatory of the characters representing native sounds used in the work, it contains an introductory description of the Tsimshian, and, best of all, a summary of the comparisons and a detailed index to the references used in the comparison, the latter prepared with the assistance of Dr. H. K. Haeberlin. In appendices III. and IV. students of American Indian languages will find useful material regarding the speech of the people among whom these myths were current. The work is also used as a medium for the publication of seven Bellabella and ten Nootka tales, by Dr. Livingston Farrand and Mr. George Hunt respectively.

The longer studies to which reference has been made are "A Description of the Tsimshian, Based on Their Mythology" (pp. 393–477), a treatise on "Tsimshian Society" (pp. 478–564), and finally the "Comparative Study of Tsimshian Mythology" (pp. 565–871), already mentioned as the crowning feature of this work.

While the value of myths as sources of information regarding the general ethnology of the tribe from which they were collected has frequently been commented upon, so far as I am aware we have here the first attempt to write an ethnological description based entirely upon them. For this reason, if for no other, the result is of interest. It shows that Tsimshian stories contain an incomplete, but upon

the whole trustworthy, picture of native life and thought. On the one hand this must be supplemented by the introduction of matters too well known among his people to be explained by the storyteller, and on the other by determining in how far the conception of what ought to be in the social and religious lives of the people conformed to things as they actually were.

The discussion of Tsimshian society derives a large part of its importance from the fact that it concerns one of the two areas over the data from which controversies regarding "the origin of totemism" have raged most violently. Evidence of the entire absence of such a thing as totemic taboos and of the importance of the father's as well as the mother's clan in the life of the individual are therefore of interest, as also the comparative study of the distribution of crests among the matrilineally organized peoples of this region. The general discussion of totemism on pages 515 to 519 should be read carefully by all interested in that subject.

In his treatment of the evolution of the north Pacific clan systems Professor Boas follows his usual cautious method. He criticizes adversely the reviewer's theory regarding a former extension of the Tlingit over what was later the Tsimshian coast, as also his suggestion that Haida moieties have arisen as the result of the amalgamation of two distinct peoples. The evidence for the former view was, however, not entirely traditional, being based partly on the presence of a considerable number of animal names in Haida identical with those in Tlingit, and the comparative lack of similar Tsimshian names, although in historic times relations between the Haida and Tsimshian were much more intimate than between the Haida and Tlingit.

To prepare the comparative study of Tsimshian mythology an enormous amount of painstaking work was necessary, particularly in the analysis of the various versions of the Raven legend, and future students will be saved an incalculable amount of labor. Two or three more efforts of the same kind would result in the much-desired concordance. The results of this comparison are summarized on pages 872–881, the more important points being the following.

As forecasted in Boas's "Indianische Sagen," published in 1895, Tsimshian mythology is distinguished from the mythologies of other Pacific coast peoples by the presence of a large number of tales of inland origin. An examination of the content of the material generally shows "that there are a number of very simple plots, which have a wide distribution, and which are elaborated by a number of incidents that have a very wide distribution and occur in a variety of plots." Comparing European and North American folk-lore Professor Boas finds that "European folk-lore creates the impression that the whole stories are units and that their cohesion is strong, the whole complex very old. The analysis of American material, on the other hand, demonstrates that complex stories are new, that there is little cohesion between the component elements, and that the really old parts of tales are the incidents and a few simple plots." There is a tendency among these Indian tales to shake off many of their supernatural elements along the border of their area of distribution, but this is "counterbalanced by another tendency of tales to take on new supernatural significance." In conclusion Professor Boas has a word to say (pages 879–881) regarding the general theory of mythology, with particular reference to that widespread impression that mythic tales represent an attempt on the part of primitive man to explain the phenomena of nature. Professor Boas thinks that this belief is not justified. His conclusion is that the material presented in this work "rather emphasizes the fact that its origin must be looked for in the imaginative tales dealing with the social life of the people." Still he would probably not deny that particular applications of such tales to the explanation of natural phenomena had been attempted at a very remote period in human history.

"Tsimshian Mythology" furnishes a notable addition to the sum of myth material and to our knowledge of northwest coast enthnology, but its chief claim to distinction rests on the great advance which it registers in the com-

parative study of myths current among American Indians and in the interpretation of them.

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The Genus Phoradendron. By WILLIAM TRELEASE, Professor of Botany in the University of Illinois. Published by the University. Octavo, pp. 224, pls. 245. Price, paper, $2.00; cloth, $2.50.

It is fortunate for botanists that the author of this excellent treatise has made so thorough a revision of the genus *Phoradendron* instead of being content with merely attempting to straighten out the tangle existing in regard to the group of related forms hitherto known as *Phoradendron flavescens,* as he first contemplated. The author notes that Engelmann has shown too great a conservatism in his published studies of the various forms of species of the genus, by later withdrawing segregates of *P. flavescens* that he formerly had recognized, and that in continuing the work of Engelmann, also being influenced by his views, Torrey allowed a number of forms which he had designated as new species to lie unpublished in the Torrey herbarium. The author in addition to making a critical study of the abundant data and material of North American species collected by Engelmann, Torrey and others in the great herbaria of this country, visited those of Europe and extended the investigation to the collection of West Indian and South American species by Urban, Martins and others. This has enabled him to make a careful comparison of numerous types and variants of species of the genus, and to more carefully discriminate between varieties and species. He recognizes 262 differentiable forms, most of which he has classified as species. In this matter he apparently does not share the conservatism of Engelmann and Torrey. Of the species he now recognizes, 154 are listed from North America and 124 from South America. The genus is separated into two primary groups, the Boreales and the Æquatoriales, plants of the former are constantly without, and the latter constantly with cataphyls on their foliage shoots. Both groups contain species destitute of expanded foliage, which are well represented by *Phoradendron juniperinum* in the southwestern United States. All of our species belong to the Boreales, those of Mexico and Central America to both primary groups, and those of the West Indies and South America wholly to the Æquatoriales. These primary groups are each divided and then subdivided, making finally in all groups 55 minor subdivisions.

The book contains 224 pages of descriptive matter including very good and usable keys; these are supplemented by indexes of collectors, occurrence, and names. The illustrations, 245 full sized plates, are indeed works of art but are also true to nature. Few books of this class are so fully and beautifully illustrated. GEORGE G. HEDGCOCK

MECHANICAL PROPERTIES OF WOOD DETERMINED

A NUMBER of fundamental laws governing the properties of wood, such as those covering the relations between strength and specific gravity, and between strength and moisture content, are laid down in a bulletin just issued by the Department of Agriculture. In this publication are presented the results of about 130,000 strength tests, probably the largest single series ever run on one material, made by the Forest Products Laboratory of the Forest Service on 126 species of American woods. The laws derived from the tests cover the general relations existing between mechanical and physical properties of each species, and also the general relations existing between these properties irrespective of species.

The results ought to prove of great value wherever knowledge of the properties of wood is essential. They have, for example, made possible the preparation of accurate tables showing all the needed strength properties for the woods used in airplanes. With these as a basis, specifications can be drawn up to eliminate all material that does not meet the exacting requirements of this highly specialized use.

The data also permit of the proper choice of substitutes for woods which have become scarce or unobtainable. Here again the airplane may be cited, since the supplies of some woods ordinarily used in airplane construction are insufficient to meet the present building program of the United States and its allies.

Among the relations between mechanical and physical properties of wood for which laws have been obtained are static bending-specific gravity, impact bending-specific gravity, compression parellel to grain-specific gravity, compression perpendicular to grain-specific gravity, static bending-moisture content; impact bending-moisture content, compression parallel to grain-moisture content, compression perpendicular to grain-moisture content, shrinkage-moisture content.

The bulletin, the authors of which are J. A. Newlin and Thomas R. C. Wilson, is entitled "Mechanical Properties of Woods Grown in the United States," and is No. 556 in the Department of Agriculture series.

SPECIAL ARTICLES

A CONVENIENT NERVE HOLDER

FOR several years past in this laboratory experiments on chemical stimulation have formed a part of the routine students' work on the physiology of muscle and nerve. In these experiments we have used a nerve holder

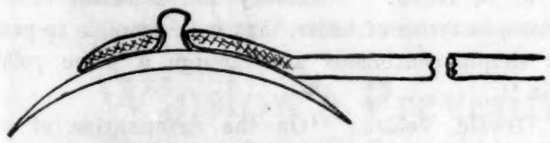

FIG. 1.

which has proved so simple and convenient that it seems desirable to suggest it to others. In its first form it consisted merely of a thin watch-glass 45 to 50 mm. in diameter, cemented by sealing-wax to the flattened end of a piece of ¼ inch lead wire 12 inches long.

If the muscle of a gastrocnemius-sciatic preparation is mounted on a muscle lever, the edge of the watch-glass may be brought very near to the muscle and the whole nerve may be allowed to lie in the liquid to be applied, as for example, a solution of sodium citrate or barium chloride.

The construction is so simple, requiring no special skill and only a few minutes of time, that it was used in this way for two or three years. Later, Mr. L. A. Ray, technician, devised the following more permanent construction. A small bit of glass rod is fused to the bottom of the watch-glass. The rod is then melted and pulled in two at a point about ½ to ¾ inch from the bottom of the glass, and is held in the flame till a small knob forms on the end. A hole is punched in the flattened end of the lead rod, the glass rod is inserted and the joint made fast with cement. The knob on the end of the glass is held firmly in place by the cement. The accompanying figure of a section of watch-glass and rod will make the whole arrangement perfectly obvious.

S. S. MAXWELL
RUDOLPH SPRECKELS PHYSIOLOGICAL LABORATORY, UNIVERSITY OF CALIFORNIA

THE URINE OF THE HORNED LIZARD

VAUQUELIN,[1] in reporting the first analysis of reptilian urine, in 1822, stated that it was composed almost entirely of uric acid, and since that time this fact has been interpreted by various observers as an adaptation to the conditions of life in arid regions, where animals obtain their only external water supply in very limited quantities in the food substances, as this type of nitrogenous excretion involves practically no water loss. The reptiles of arid regions have been known for some time to excrete practically all of their waste nitrogen in the form of uric acid and its salts, while, on the other hand, birds and aquatic and semi-aquatic reptiles may excrete considerable amounts of urea.

[1] Vauquelin, Louis Nicolas, "Examen des excrémens des serpens que l'on fait voir en ce moment à Paris, Rue Saint-Nicaise," *Annales de Chimie et de Phisique. 2me Serie,* Tome 21, p. 440, 1822. Two boas, species not stated, were the source of the urine examined in this case. Uric acid had also been associated with reptiles as early as 1793, when a "pasty deposit" found in the bladder of a tortoise by Vicq-d'Azyr was found to contain this substance.

The urine of the horned lizard is excreted in the dry form at the same time as the feces, from which it is separated by a constriction of the common mass, the material voided at any one time having roughly the shape of a dumbbell, one of the enlargements being composed of urine and the other of fecal matter. The following figures for the composition of the urine of *Phrynosoma cornutum* (specimens obtained at Alamogordo, N. M.) have been obtained recently in the laboratory of physiological chemistry of the University of Illinois, the work having been undertaken at the suggestion and under the direction of Dr. H. B. Lewis.

Constituents	Mg. per Gm. of Dry Urine
Total nitrogen	260
Urea + ammonia nitrogen	1.4
Ammonia nitrogen	1.4
Uric acid	765
Creatinine	Trace
Ash	87.5
Phosphorus as P_2O_5	3.5

It will be noticed from the above figures that uric acid accounts for practically the total amount of nitrogen present, and that there is no urea. The small amount of ammonia is probably present as ammonium urate. The ash present is mostly composed of foreign materials (sand grains, etc.) inseparable from the urinary mass and therefore weighed and analyzed with it.

A. O. Weese
The University of Illinois

SOCIETIES AND ACADEMIES

AMERICAN MATHEMATICAL SOCIETY

The one hundred and ninety-third regular meeting of the American Mathematical Society was held at Columbia University on Saturday, October 27. The attendance at the morning and afternoon sessions included thirty-five members. Professor Oswald Veblen occupied the chair, being relieved by Professor L. P. Eisenhart. The council announced the election of the following persons to membership in the society: Dr. J. V. DePorte, State College, Albany, N. Y.; Mr. J. W. Lasley, Jr., University of North Carolina; Mr. Vincente Mills, Philippine Bureau of Lands; Professor B. M. Woods, University of California. Five applications for membership were received.

A committee was appointed to audit the accounts of the treasurer for the current year. A list of nominations for officers and other members of the council was prepared and ordered printed on the official ballot for the annual election at the December meeting. The Secretary was directed to procure insurance to the amount of $10,000 on the library of the society, which is deposited in the Columbia Library.

The following papers were read at this meeting:

R. D. Carmichael: "Elementary inequalities for the roots of an algebraic equation."

Louise D. Cummings: "The two-column indices for triad systems on fifteen elements."

G. A. Pfeiffer: "On the continuous mapping of regions bounded by simple closed curves."

J. F. Ritt: "On the differentiability of asymptotic series."

W. B. Fite: "Concerning the zeros of the solutions of certain linear differential equations."

J. E. Rowe: "Hexagons related to any plane cubic curve."

G. D. Birkhoff: "On a theorem concerning closed normalized orthogonal sets of functions with an application to Sturm-Liouville series."

Edward Kasner: "Systems of circles related to the theory of heat."

O. E. Glenn: "Systems of invariants and covariants of Einstein's theory of relativity."

J. K. Whittemore: "Theorems on ruled surfaces."

R. L. Moore: "On certain systems of equally continuous curves."

R. L. Moore: "Continua that have no continua of condensation."

J. R. Kline: "Necessary and sufficient conditions, in terms of order, that it be possible to pass a simple continuous arc through a plane point set."

Oswald Veblen: "On the deformation of n-cells."

Oswald Veblen: "Deformations within an n-dimensional sphere."

The San Francisco Section met at the University of California on October 27. The Southwestern Section will meet at the University of Oklahoma on December 1. The Chicago Section will meet with the Mathematical Asssociation of America at the University of Chicago on December 28–29. The annual meeting of the society will be held at Columbia University on December 27–28.

F. N. Cole,
Secretary